

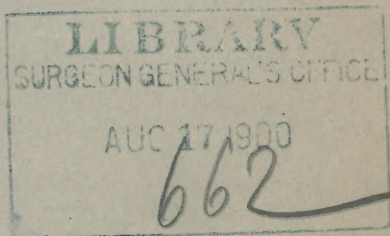
Cushing (H. W.) writes again
Harvey Cushing

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of the Spine.*

*A Report of Two Cases, with Recovery following Symptoms
of HemileSION of the Cord.*

BY

HARVEY W. CUSHING, M.D.,
RESIDENT SURGEON OF THE JOHNS HOPKINS HOSPITAL.

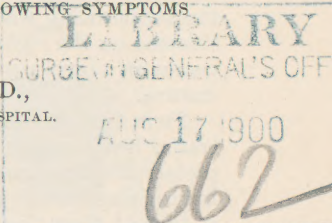


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HÆMATOMYELIA FROM GUNSHOT WOUNDS OF THE SPINE.

A REPORT OF TWO CASES, WITH RECOVERY FOLLOWING SYMPTOMS
OF HEMILESION OF THE CORD.

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GUNSHOT injuries of the spinal column are of comparative rarity. The mortality of cases with symptoms of cord lesion, especially in the cervical region and without operative interference, reaches a high percentage.¹

In those cases which recover, the nature of the lesion is often difficult of determination, the disturbances of motility and sensibility giving clue alone to the spinal segments involved and the transverse extent of the injury, but not to its pathological anatomy.

In each of the following cases the missile lodged in the centrum of a vertebra without direct injury to the cord; but, nevertheless, produced symptoms of hemileSION. A study of their symptomatology, with a discussion of the character of the lesion, is contained in this communication.

Both cases illustrate some unusual features of a type of the so-called Brown-Séquard paralysis; the value of the x-rays in locating the offending bullet; practical recovery without operative interference; a residuum of symptoms resembling syringomyelia.

CASE I.—The patient, a young woman, aged twenty-seven years, was brought into Prof. Halsted's service at the Johns Hopkins Hospital, November 6, 1896, with a history of having been shot a few hours before entrance. Her assailant was standing on her right side a few feet from her. Two shots were fired. She was sitting at the time, and fell forward on to a table, bleeding from the mouth; a plate of upper teeth, which she was wearing, was driven out by the bullet. At the second shot she fell to the floor, and it seemed to her that her limbs had become stiff, and there

¹ In the American Civil War 642 cases of gunshot wound of the spine of all varieties were reported, with a fatality of 55 per cent. The cervical cases alone reached 70 per cent. Chi-pault (*Etudes de Chirurgie Médullaire*. Paris, 1894) has collected 104 cases from 1850 to 1891, with operation and recovery in 60 per cent. The mortality without operative interference reaches 80 per cent., and life, for the 20 per cent. surviving, was hardly worth the living. The consensus of opinion (cf. Vincent, *Revue de Chirurg.*, 1892) recommends operation unless there is total transverse lesion indicated by abolition of knee-jerks.

was a sensation in the right calf as though it were swelling up and would burst. In a few moments her arms began to tingle, so that they could not be touched. She lost consciousness at no time; there was no vomiting. At entrance, examination revealed three bullet wounds; two small characteristic wounds of entrance with a tattooing of powder grains about them, and the third a ragged wound through the soft palate. (This, with the upper of the entrance wounds, situated just above and anterior to the right tragus, we may dismiss with a word; both healed rapidly; there was a resulting otitis media, doubtless from tubal infection due to the suppurating wound in the mouth.) The other entrance wound was situated on the right side of the neck at the anterior border of the trapezius on a level with the cricoid cartilage. About this our chief interest centres.

From the notes taken six hours after the injury. "The patient lies prostrate; head turned to the left; arms not drawn up; respiration completely diaphragmatic; no dyspnoea; temperature 98.6°; pulse 60. She is groaning from "pain," especially severe in the arms. The sensation is that of their 'being asleep;' a 'pins-and-needles' feeling, but of an exaggerated and agonizing character. This same sensation is present in the right leg, and to a less degree over the abdomen and down the left leg. It is intensified by the slightest touch or by the pressure of the bedclothes, and is so severe that she cries out. It seems to be more or less paroxysmal and associated with slight muscular contractures. The pupils are equal, contracted, and react to light; the right palpebral fissure seems smaller, but this may be due to the slight swelling of that side of the face. Tongue protrudes in the median line. A marked tremor of the lips in speaking. No oral, visual, or cerebral disturbances made out.

Motor symptoms: "There is a right-sided hemiplegia below the level of the deltoid, biceps, and supinator longus muscles. There is some power, therefore, in flexion and abduction of the arm, but only with the greatest effort. She says, 'It is heavy,' and the attempt apparently exhausts her. The arm tends to remain in the slightly flexed and abducted position which it has reached. The left leg she is able to move in every direction, but only with the same fatiguing effort. In the left arm a condition is present similar to, but less pronounced than, that in the right. Flexion, abduction, and outward rotation are possible; slight motion is possible in the fingers in flexion. No extension. All motion accompanied by the same feeling of heaviness and fatigue."

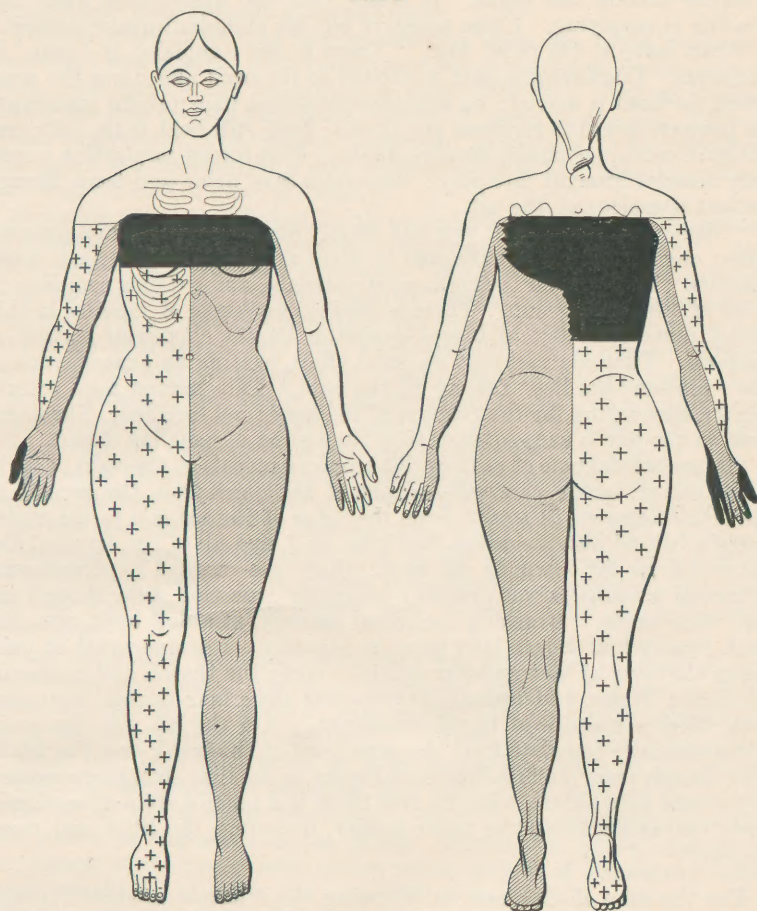
Sensory symptoms: "Analgesia, apparently complete, is present in the left leg. A pin-prick is recognized as a touch; a pinch, as pressure. There is hyper-sensitiveness to impressions of pain in the arms. Tactile sense, on superficial examination, seems everywhere normal, though touching or moving the limbs makes her cry out, and the examination was unsatisfactory, as was also the attempt to determine the presence of muscle-sense. It seemed present on both sides. Thermic sensibility uncertain on the left side, and apparently absent in the right hand.

"Reflexes (six hours after injury): Both knee-jerks are present, the right much less active. No superficial reflexes obtained.

"There exists a marked disparity of temperature on the two sides of the body; so much so that even the nurse's attention was attracted by the great surface heat on the right side, especially noticeable in the upper extremity. The patient has voided no urine."

Twenty-four hours after entrance. "The patient passed a wretched night, crying out with the pain in her arms; little relief from morphia; pyrexia

FIG. 1.



Sensory disturbances on admission.



Anaesthesia to Pain and Temperature.



Hyperaesthesia.



*Total Anaesthesia.**

of 102° by midnight (ten hours after injury); no disparity of surface temperature on two sides of body was appreciated this morning. She is unable to recognize the position of the right leg. There seems to be

* Sensibility to tactile stimuli may not have been completely absent over the whole body zone.

a reduced tactile sensibility in the left lower leg and over the right thigh and foot; patient says, 'they feel dead.' Sphincter ani relaxed; after an enema the rectal contents have dribbled away. Urine passed involuntarily during the night. It seems that she appreciates when her bladder is emptying. Urine negative but for abundant uratic deposit."

From notes on the third day. "There is less complaint of 'pain' in the arms. Considerable pain is elicited in the neck and down the arms when the head is moved; no spontaneous spinal pain; slight tenderness on pressure over the vertebra prominens; head still held to the left; respiration continues purely diaphragmatic; with forced inspiration accessory muscles brought into play; incontinence of urine and feces, though patient conscious of the act.

"Motor paralysis in left arm has largely disappeared; all motions possible; chief weakness in extensors of elbow and wrist and intrinsic hand muscles. Paralysis on the right as at entrance, and extends complete to level of fifth root group. There is distinct weakness of muscles in this group, namely, of deltoid, biceps, supinator longus, clavicular portion of pectoral. They contract only on great effort, causing an exacerbation of the 'pins-and-needles' feeling in the arm. This paresis may extend higher, accounting for the position of the head; not certified. The knee-jerk on the left is exaggerated, with suggestion of patellar clonus.

"More careful note of sensory disturbances reveals on the right (Fig. 1) —the side of motor paralysis—a zone of analgesia from the second to the fifth interspace in front; from the spine of the scapula to the costal margin behind and including the right hand, and all of the arm but the outer side as far down as the wrist, where was marked hyperæsthesia. (Thermal anæsthesia was probably complete over this zone, though no tests were made. Brushing the actual cautery, at a dull heat, over the back twenty-four hours later gave no sensation of temperature or pain below the level of the scapular spine.) Over the thumb and border of the index finger, and approximately over the ulnar dorsal cutaneous area, there is absence of tactile sensibility.¹ On the left side analgesia was practically complete from the same level on the trunk over the whole side, though from the fifth intercostal space to the iliac crest there seemed to be some pain points. In the arm there is a narrow strip of analgesia from the axilla along the ulnar border, including the little and ring-fingers."

For the sake of clearness in following the different groups of symptoms through the subsequent history, it seems advisable to take them up and discuss them individually rather than to leave them grouped, as in the daily notes.

A word as to the general progress. There had been pyrexia of 2° following the night of admission. Forty-eight hours after the reception of the injury a chill, with further elevation of temperature to 104° and 105°, ushered in an attack of pneumonia, with a large patch of basal consolidation on the side of the lesion. This is apparently a not uncommon occurrence in cases of cervical lesions, though one finds no special mention of its importance. It possibly bears some relation to the intercostal

¹ Accurate observations in the hand were very difficult. It seemed that after the hyperæsthetic areas had been stimulated, from attempts to determine their boundary, she would interpret touch as pain, over fields apparently analgetic to previous stimuli.

paralysis. This, for the time being, set aside all thought of operative interference. Distinct signs of consolidation remained in the chest for ten days. There was a gradual subsidence of pyrexia, which took twenty-eight days to reach a normal level.

For the month following this pneumonia there was rapid motor improvement and gradual disappearance of the annoying subjective symptoms. She was up and beginning to walk quite well. The succeeding month was one of discouragement, return of pains in the arm, difficult spastic progression, and various unpleasant symptoms to be described. This again was followed by a slow improvement to her present excellent condition six months after the injury.

Subjective symptoms. It is difficult to describe the patient's sensations. As Gowers says, "Our sensations transcend our vocabulary." She said it seemed as though her arms were "badly asleep," which may come under the category of "pins-and-needles" sensations or of numbness and tingling. The subjective impression was one of pain. For the first few days it was distressing to see her. These sensations were present, persisting in the left arm for a day or so, to give place to one of itching, then to one of burning, and finally to radiating pains which were the precursors of the return of motor power, and the exodus of all subjective symptoms, except for some stiffness and numbness in the finger-tips.

This same cycle was subsequently observed in the right arm: (1) agonizing numbness and tingling, subsiding by the fourth day; (2) pruritus so severe that on the fifth day she said, "I could tear it to pieces;" (3) burning sensations complained of in the second week, and, finally, (4) lancinating pains. The patient recognized this sequence, and said that she ought to move her fingers soon, which she did on the twenty-eighth day.

Four days after the injury complaint was first made of a belt sensation, which was located about at the costal margin: "I get so tight across my stomach, I think I will burst," she frequently remarked. There was no meteorism at this time. "Girdle pain" Gowers considers of much practical importance, as it evidences the existence of inflammatory and degenerative processes, and indicates a level at the upper border of an injury when transverse. Here it was certainly below the area which corresponded to the lesion. Perhaps in partial lesions it may appear at the lower level, a view which several of Thorburn's cases would uphold.

At the end of the second month, during the period of non-improvement above mentioned, there was a return of this girdle sensation, and, curiously enough, the constriction seemed to her much tighter on the right, the paralyzed side, than on the other. It corresponded to a belt of hyperæsthesia to be described. Other disagreeable sensory disturbances appeared at this time. There was great complaint of cold feet; they felt icy to the touch and the usual measures failed to give relief. The anæsthetic leg was slightly burned several times by attempts to warm it. The spastic condition of the right leg was at this time in greatest evidence. She had a sensation of stiffening and becoming rigid when she first attempted to walk, or to turn in bed after being quiet for awhile. "I feel stretchy," she would say. "Cutting" pains appeared in the right arm, intensified with the least handling, and located about the upper arm, and in the flexor tendons of the wrist; her nights were almost sleepless. Extreme hyperæsthesia of the lower arm, as at

the side of the trunk girdle, reappeared, and only very gradually wore away, lingering in the ulnar half of the arm for a couple of months, where a trace of it still remains.

The reflexes. At the first examination the deep reflexes were present, moderately active in the left leg, much less so on the right, the side of paralysis.

Forty-eight hours later myotatic contractions on the left were much exaggerated with a distinct quadriceps clonus; reflexes on the right feeble.

At the end of four days the right knee-jerk could not be obtained, and the left was much less active. This condition held for three days, when there was a gradual reappearance of reflexes, becoming more and more active, especially on the side of the motor paralysis and concomitant with its disappearance.

[Of this sequence of reflex activity there seems to be no special mention in the bibliography. The persistent abolition of reflexes in total transverse lesions in man, first noted by Bastian,¹ and recently emphasized by various authors,² is now well recognized. In partial lesions with degeneration of the pyramidal tract, early suspension and subsequent increase in a few hours or days is supposed to be the rule, and in hemileSION on the side of injury alone. An early enfeeblement, subsequent loss, and final return with exaggeration, as in our case, were noted by Kocher³ in his remarkable case of hemileSION from stab high in the cervical cord. The weakened reflexes had disappeared by the seventh day, to return on the eleventh, and by the fourteenth were greatly exaggerated, the knee-jerk on the opposite side remaining constantly normal. Similarly, in one of Thorburn's⁴ cases, cursory note is made of it, and Ferrier,⁵ in a case of transverse lesion in the ape, noticed this temporary obliteration of the reflex phenomena coming on some days after the injury. This sequence in partial lesion may be of more common occurrence than has been noted.]

Following their reappearance, the deep reflexes become progressively more active. By the sixteenth day an ankle-clonus was obtained, which soon became so marked that a slight pressure on the plantar surface occasioned it, and similarly a clonic contraction of the quadriceps by simply touching the upper border of the patella.

At this time a triceps and supinator reflex and myotatic contractions also of the flexor and extensor group of the right arm were readily obtained by light tendon rappings. Up to the present time, though to a less degree, these deep reflexes on the side of the former paralysis remain exaggerated. The extreme activity wore away in a few months.

A return of the abolished superficial reflexes was not observed until the end of the second month.

¹ H. Ch. Bastian: "On the Symptomatology of Total Transverse Lesions of the Spinal Cord, with Special Reference to the Condition of the Various Reflexes." *Med. Chir. Trans., Lond.*, 1890, lxxiii. p. 151.

² E. S. Reynolds: "The Condition of the Reflexes in Total Transverse Division of the Spinal Cord." *Brain*, 1895, xviii. p. 148.

H. W. Page: "Three Cases of Fracture-dislocation of the Spine with Total Transverse Lesion of the Spinal Cord." *Lancet*, London, February 8, 1896, p. 339.

³ Theo. Kocher: "Die Verletzungen d. Wirbelsäule zugleich als Beitrag z. Physiolog. d. menschlichen Rückenmarks." *Mitteilung. a. d. Grenzgebiet. d. Med. und Chir.*, 1896, Bd. i., S. 415.

⁴ Wm. Thorburn: "A Contribution to the Surgery of the Spinal Cord." Case xv., p. 45.

⁵ D. Ferrier: "Recent Work on the Cerebellum and its Relations." *Brain*, 1894, xvii. p. 14.

There was an early involvement of the reflex acts of defecation and micturition. After the first forty-eight hours of lack of control, obstinate constipation ensued, and only very recently has the patient found enemata unnecessary for an evacuation of the bowels. During the first few weeks there was considerable meteorism, and peristaltic movements were evident through the abdominal wall. The urine was passed without control for a few days, but she soon could appreciate when her bladder was full, and would call attention to it. Some dribbling persisted for a month or two. There was no complicating cystitis. The menstrual period, which, before the injury, had occurred every two or three weeks, showed itself as a slight discharge on the second day after the injury, and not again for nine weeks. Catamenia since then have been normal.

During this whole period there was constant evidence of vasomotor disturbance; the right hand was often noted as being very warm, and the patient complained of flushes in it. There was a very perceptible increase of the secretion of sweat on the right side, which frequently would drip from the axilla when the arm was bared for examination. This hyperidrosis is still present. There was marked hyperæmia following a pin prick also on that side.

Motor disturbances. As stated in the early clinical note, the motor paralysis on the left side was a transitory one, all motions being possible in the arm after a few days, and the resulting paresis, though lingering for a few weeks chiefly in the extensor group and intrinsic hand muscles, by the second month had entirely disappeared. At present there is complete restoration.

The right hemiplegia was somewhat less early in its subsidence. Following the return, and with the exaggeration of the deep reflexes, motion was first observed on the tenth day as a slight contraction of the quadriceps, and by the throwing into prominence of the extensor tendon of the great toe when a futile attempt was made to raise the foot. Motion then rapidly returned and in four days was possible in all directions. Muscular power was soon largely regained everywhere except in the dorsal flexors of the foot.

[This seems to be the customary period before return of motion after degeneration of the pyramidal tract, the quadriceps muscle usually giving first evidence of it. In Kocher's case of hemilesion, above cited, it was seven days. In the light of Turner's interesting experiments on hemilesion,¹ it would seem to indicate the time necessary for decussating motor neurones from the opposite half of the cord to assume the function of those on the injured side.]

The *nutrition* of the patient at this time had begun to suffer greatly, though a fair amount of nourishment seemed to be taken. In a note on the twenty-second day after injury: "Muscular wasting and improvement in muscle power seem to be in inverse proportion. The patient is becoming quite emaciated; breasts are atrophied; ribs prominent; tissues, especially in paralyzed leg, are flabby, with atrophy most marked in the calf. Electrical reaction shows no loss of irritability to faradic current."

Of a series of measurements taken, this change is shown most strikingly in the right calf, with culmination of atrophy in the third week after return of motion:

¹ Turner: "On Hemisection of the Spinal Cord." Brain, 1891, xiv. p. 496.

	Right.	Left.	
10th day,	32 cm.	32 cm.	Paralysis of right leg; return of reflexes.
16th "	31 "	31½ "	Motion returning; exaggerated reflexes.
23d "	29¾ "	31 "	Motion possible in all directions.
30th ¹	29¾ "	31½ "	Motor strength increasing.
37th "	30¾ "	32½ "	Sitting up; massage.
59th "	31½ "	33 "	Walking; spastic gait.
75th "	32¾ "	34 "	Gaining weight.
198th "	33½ "	35½ "	Present condition.

On the thirtieth day motion was possible in the abdominal muscles, and soon after it appeared feebly in the intercostals. At this time she was encouraged to get up, and soon after was able to take a few steps, though she was very unsteady and required support. The weakness of the dorsal flexors of the foot on the paralyzed side became very evident; she could not lift the foot from the floor, but dragged it along in a typical late hemiplegic fashion.

[To this resultant leg paresis, invariably selecting a certain muscle-group, Ludwig Mann² has recently called special attention. That its character was constant, independent of the level of lesion of pyramidal tract fibres, from the cerebral cortex to lumbar enlargement, was brought out by Wernicke.³ Mann has demonstrated that it confines itself to a certain co-ordinate muscle unit (*Bewegungseinheit*) which has a definite function. Restitution of muscle power, though otherwise complete after pyramidal tract degeneration, invariably selects those muscles which he calls the "shorteners" (*Verkürzer*), namely, the dorsal flexors of the foot and the flexors of the leg, whose combined muscle action is that of lifting the leg in the second stage of walking, when the foot is raised from the ground. This residuary paralysis is responsible for the peculiar gait described as hemiplegic. A considerable weakness of the dorsal flexors of the foot remains in our patient to this day. Other muscles of this unit Mann has shown to be the iliopsoas, the tensor fasciæ latæ, the gracilis, and the sartorius. Paresis of the two latter, as flexors of the leg, is readily demonstrated when the patient lies on her face and the leg is hyper-extended by placing the hand under the knee so as to relax the hamstring muscles. While in this position the power of flexion of the leg is very evidently weak in our patient. The hamstring muscles themselves, though flexors ordinarily, in the act of walking are extensors and belong to the muscle group of the first stage of walking, the lengtheners.]

On the twenty-seventh day, after the period of lancinating pains and increased reflexes, was first observed the faintest trace of motion in extension of the right index-finger (twenty-two days in Kocher's case of hemiplegia, above cited). Return of motion was soon evident in the extensors of all the fingers, in the triceps, the costal part of the pectoralis major, in extension of the wrist, flexion of the wrist, flexion of the index and middle fingers and thumb, such as would be expected with the gradual return

¹ The patient's weight had dropped at this time from 138½ to 116 pounds.

² Mann: "Klinische und anatomische Beiträge zur Lehre von der spinalen Hemiplegie." Deut. Zeit. f. Nervenheilkunde, 1896, Bd. x, Heft. 1, 2, pp. 1-66.

³ C. Wernicke: "Zur Kenntniss der cerebralen Hemiplegie." Berliner klin. Woch., 1889, Bd. xxvi, No. 45, S. 969.

of function in the spinal segments from above downward, no reaction of degeneration having been obtained in any of the paralyzed muscles. Reaction followed this rapid improvement, and during the aforementioned third month motor change was at a standstill. Progression, which up to this time had steadily bettered itself, became less easy, the gait more spastic, clonic muscular contractions starting up when she bore any weight on the foot. This period was signalized by the above-described subjective disturbances and by the appearance of trophic changes in the right hand. The hand became much swollen, the skin shiny and tense, obliterating all furrows, the fingers very stiff, painful, and distinctly tapering, the nails convex and painful when touched. Across the nails had grown out slightly elevated whitish transverse ridges. These measured about 4 mm. in width on the right finger-nails. Similar ridges, though much less broad, were present on the nails of the little and ring finger of the left hand, corresponding to the transitory disturbance there. Pains of a cutting character appeared with numbness, flushes, and all so distressing that passive movement was precluded for a few succeeding weeks until these disturbances began to wear away. Since then there has been an uninterrupted improvement in muscle power.

[These nutritional disturbances, as J. K. Mitchell¹ points out, may occur at any time, and do not belong to cases of complete destruction, but are met with only when there is partial injury. He says, further, that they usually appear when the wound is healing, and their duration varies from weeks to permanence. He holds to the view that it is a loss of trophic control rather than an abolition of trophic function.]

At the present writing there persists inability to completely close the hand, especially the little and ring fingers; inability to oppose the thumb and little finger; marked atrophy of the abductor indicis.

Sensory symptoms.—The analgesia described as present on entrance over the left side below the second intercostal space and down the inner side of the arm, as well as over the right chest and arm, had been gradually disappearing, and in the right arm had been replaced by extreme sensitiveness to painful stimuli. By the second week a pin prick was recognized as such, though she said "it does not feel sharp." A pinch was no longer mere pressure. Some hyperalgesia still persisted on the right lower extremity, but in greatly lessened degree. Tactile sensibility had also largely returned over the areas of total anæsthesia.

During the above-mentioned period of retarded improvement more careful observation of the sensory disturbances revealed an interesting condition which makes it a matter of regret that the sensibility to thermic impressions had not been more carefully noted in the interim. After the first note of uncertain perception of temperature on the left side and its absence in the right hand, but few observations were made. At the time of the pneumonia (four days) it was noticed that brushing the Paquelin cautery over the right back gave no sensation below the level of the spine of the scapula. This corresponded to the analgetic zone. Subsequently (sixty days) the hot water cans, applied to her cold feet, gave no sensation of warmth, and burned the left leg in several places. This led to more careful examination, with the following result. (Fig. 2.)

¹ J. K. Mitchell: Remote Consequences of Injuries of Nerves. Philadelphia, 1896.

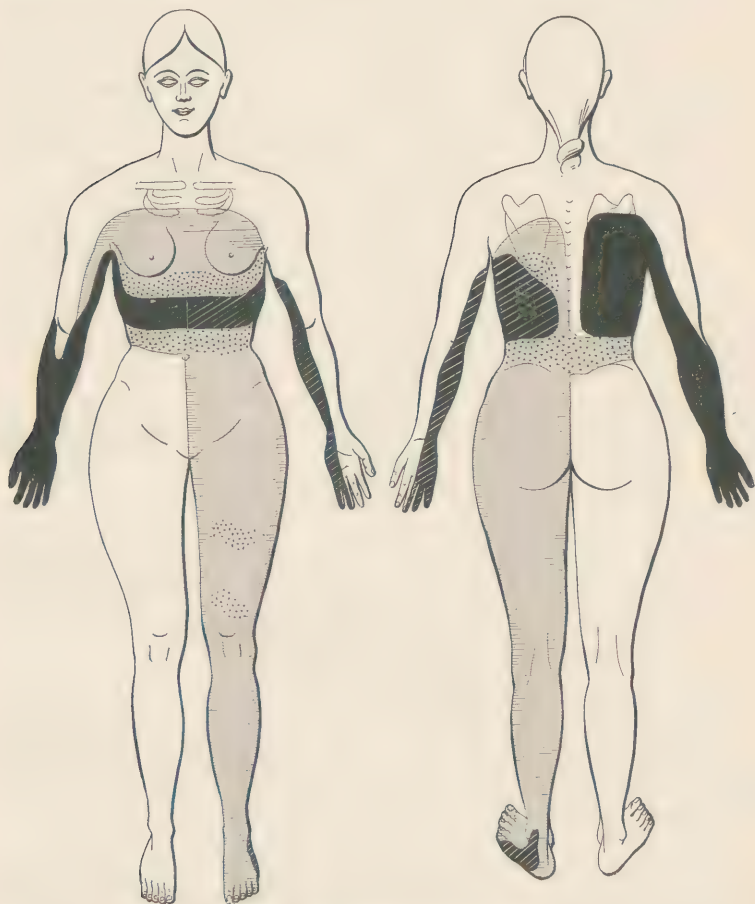
In general, sensation to cold (tested with a camel's-hair brush moistened with ether) was lost from the second interspace over the whole left side of the body. It was recognized as warmth to a zone (see Fig. 2) about 10 cm. wide, beginning at the level of the seventh rib in the mammary line, where it was interpreted simply as pain, a "pins-and-needles" sensation closely akin to the early spontaneous ones, so severe that she would draw away and almost cry out. The boundaries of this zone were very definite. Above and below it were border-zones over which she would say "it is beginning to pain, but still feels warm." Over the whole leg below cold was recognized as warmth, but there were isolated areas with ill-defined boundaries over which it gave a slight sensation of pain. On the right front at the same level a similar condition existed; the pain, however, being distinctly more severe than on the left. Over the back this zone, where cold produced pain, was more widespread, especially on the right side, extending practically over the old areas of analgesia from the spine of the scapula. Curiously enough, the areas did not seem to meet at the median line behind. It included the whole right arm except the outer surface of the upper arm and slightly below the elbow, which is practically the sensory distribution up to the fifth root, as we shall see, the upper limit of lesion. The sensation of pain was especially intense in the fingers and hand. For convenience and from its chief characteristic, we have called this area across the body and arms the "cold-pain" zone. A gap of normal sensibility existed between the thoracic zone and the area of the left arm, which extended from below the axilla along the inner side, including the little and ring fingers. (This represents the first dorsal root distribution and probably the level of injury to the left half of the cord.) A small distinct area where cold produced pain was also demonstrated under the left external malleolus and outer border of the foot.

Heat (tested by tube of warm water) on the left side of the body conveyed no temperature sensation whatever, and was simply recognized as touch. Over the "cold-pain" areas of the chest and arm, however, when near the boiling-point it gave a slightly painful sensation (without thermic impression) of the same kind as the pain from cold. On the right its perception was normal everywhere, except over the "cold-pain" body zone and in the arm, where pain was associated, and, as with the stimuli of cold, more marked than on the left. (We must bear in mind the slight hyperalgesia of the right and the fading analgesia on the left at this time. The mere pressure of a tube at body temperature on the right gave the same sensation of pain, though less marked than the hot tube.) Over the old zone of anæsthesia from the second space to the "cold-pain" areas, heat perception was present, but dulled.





Tactile impressions (tested with a wisp of cotton) were distinctly blunted over the whole left side, chiefly just below the second interspace, down the inner side of the arm and under the left outer malleolus, where they were about absent. On the right persisted also the diminished tactile sense below the second space. Over the "cold-pain" areas of the trunk and right arm a sensation of pain, of "pins and needles," was elicited with the gentlest tactile stimulus, and it was believed that there was a complete abolition of tactile sense. That this was not the case, however, was demonstrated by Dr. Barker by means of von Frey's æsthesiometer, with which a distinct sensation of touch without pain could be called forth with the pressure of a fine hair, though the threshold for pain

was so low that a deeper pressure of the same hair would produce a sensation of pain.

FIG. 2.



Thermic disturbances (second month).

- | | | |
|---|--|----------------------|
|  | Areas of extreme "Cold Pain." | } Thermo-anaesthesia |
|  | "Cold Pain" less extreme. | |
|  | Cold as warmth with some pain. | |
|  | Cold interpreted as warmth. No thermic response to Heat. | |

[Two interpretations may be given to the above-mentioned sensory phenomena, depending upon the presence or absence of special nerves for pain. One rests upon the possibility of a transmission of painful

impressions by sensory nerves other than those whose special function it may be to convey sensations of pain. This interpretation of Goldscheider and others is most generally accepted. Gowers,¹ for instance, speaks of the sensation of "pins and needles" which all stimuli called forth in our case and which the patient called "pain," as "representing the highest degree of excess of impressions conveyed by the nerves of tactile sensibility." Granting this view, we must consider that over the "cold-pain" areas on the right all forms of stimuli produce pain from the irritability of their respective conducting paths, namely, for touch, pressure, or thermic impressions. On the opposite side there is practically an interruption of heat conduction with a diminished irritability of tactile and pain tracts, the cold paths alone being extremely irritable and ready to call forth pain. The fact that pain from cold stimuli is about equal on the two sides, remembering that partial analgesia existed on one, with hyperæsthesia to pressure pain on the other, would favor this view as opposed to the second less commonly accepted interpretation, namely, that sensations of pain can be transmitted only by the special nerves set apart for that purpose and not at all by nerves subserving tactile and thermic sensations. This latter view is championed by von Frey,² who, with others,³ has brought forward most convincing arguments in its support. It is interesting here to note in its favor that the character of pain produced by all manner of stimuli was alike, and the same as the spontaneous pain while that lasted, namely, a "pins-and-needles" sensation. The only spontaneous pain at the present time is located in the right arm and described as "darting." This is the sort of pain which cold provokes now. Also while the "pins-and-needles" feeling was present the patient at one time volunteered the remark that the ether and brush felt just like the pin prick, but that there were myriads of points. Most of the thermic and other sensory disturbances could be explained under either interpretation. No attempt was made to isolate individual pressure, thermic, and pain points.

The subject involves, of course, the discrimination between specific nerve fibres for the various modalities of sensation, not only in the peripheral nerves, but also in their indirect intramedullary continuations (sensory neurones of the second and of higher orders), but the topic is at present too unsettled to justify further discussion in this place.]

To summarize, there existed on the left, beside a general slightly sub-normal sensibility to pain and tactile impressions, perverted recognition of thermic stimuli to cold and absence of recognition of warmth. In addition, over the area for convenience called the "cold-pain" zone, cold produced no sensation other than pain even when near body temperature. Heat similarly produced no thermic impression, but called forth pain only at high temperatures. On the other hand, on the right side, with the exception of slight hyperæsthesia to pain, sensations were practically normal below this "cold-pain" zone. Over it, however, existed extreme hyperæsthesia to pressure and pain. Cold produced pain alone

¹ Gowers: *Diseases of the Nervous System*, 1893, p. 219.

² v. Frey, M.: *Untersuchungen ueber die Sinnesfunctionen der menschlichen Haut*. *Berichte der math.-phys. Cl. der K. Ges. d. Wiss.* 2 Juli, 1894, 3 Dec. 1894, and 4 März, 1895; also, *Druckempfindung und Schmerz*. *Abhandl. der math.-phys. Cl. der K. Sächs. Ges. der Wiss.*, Leipzig, 1896, Bd. xxiii. No. iii.

³ L. F. Barker: "A Case of Circumscribed Unilateral and Elective Sensory Paralysis." *Journal of Experimental Medicine*, 1896, i., No. 2.

without thermic impressions, and more severe than on the left; heat gave a normal sensation with the additional factor of pain, slightly more marked than that produced by mere contact. These observations would seem to indicate a dissociation of heat and cold paths in the cord as well as the more often noted dissociation of the combined thermic and the pain tracts.

These sensory disturbances for ease of comparison are here tabulated:

I Over those areas spoken of as the "cold pain" zone (Fig. 2, black).

Right.	Left.
<i>Pressure or touch</i> : Present and unimpaired. (?) Low threshold for pain makes its recognition difficult.	Present, slightly dulled.
<i>Pain</i> : Greatly exaggerated.	Slightly dulled.
<i>Cold</i> : Recognized as severe pain without thermic impression.	Recognized as pain without thermic impression, but less acute than right side.
<i>Heat</i> : Recognized as pain which is slightly greater than that produced by mere pressure. ¹	No thermic impression whatever; pain when near boiling-point.

II. Elsewhere over the body below this level.

Right.	Left.
<i>Pressure and touch</i> : Unimpaired.	Slightly dulled.
<i>Pain</i> : Slight hyperæsthesia.	Slight anæsthesia.
<i>Cold</i> : Normal thermic sensibility.	Recognized as warmth ² (some pain).
<i>Heat</i> : Normal thermic sensibility.	Absence of thermic sense.

A month later (ninety-two days) the intensity of these sensory disturbances had abated. The extreme hyperæsthesia had diminished over the "cold-pain" zone on the right. Pressure over circumscribed areas with test-hairs showed that the threshold for pain above noted had receded somewhat, though it was still low. Heat and cold were on this side everywhere recognized as such. At this time some gross observations were made to determine the sensory threshold values over these areas, with the following result: In the neck above the level which corresponds to the lesion, the threshold for pain as elicited by heat stimuli was 52° C., while a temperature of 40° C., which feels but slightly warm to the neck, causes distinct pain with recoil over the "cold-pain" zone on the right side, and feels "hot." Here also the cold tube at 35° C. gives an acute sensation of pain. Over the zone on the left, the slightly analgetic side, the threshold of pain as tested with heat stimuli was high, a temperature near the boiling-point being necessary to produce it, and only at this high temperature was there any thermic impression per-

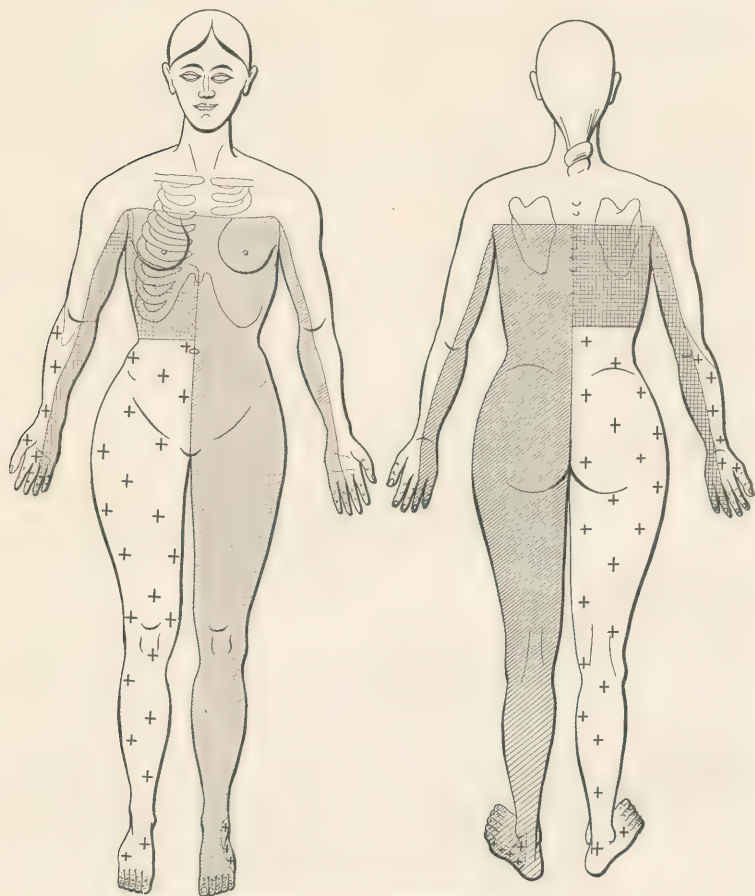
¹ We should have been able, possibly, on this side, had the tests been conducted with greater precision, to produce pure thermic impressions without accompanying pain, by delicate warm stimuli, as with the pressure-points, which were shown to be capable of stimulation without eliciting pain.

² This need not necessarily be interpreted as a paradoxical temperature-reaction, inasmuch as relatively mild irritation of pain-nerves may give rise to a sensation of "heat" or "burning." (Barker.)

ceived. Cold produced pain, as on the right, when only a little below the body temperature.

Status præsens (six months after the reception of injury). There is

FIG. 3.



Touch and pain (sixth month).



Slight anaesthesia to pain and touch.



*Great hyperaesthesia to pain. (Threshold very low.)
Touch unimpaired.**



Slight hyperaesthesia to pain.

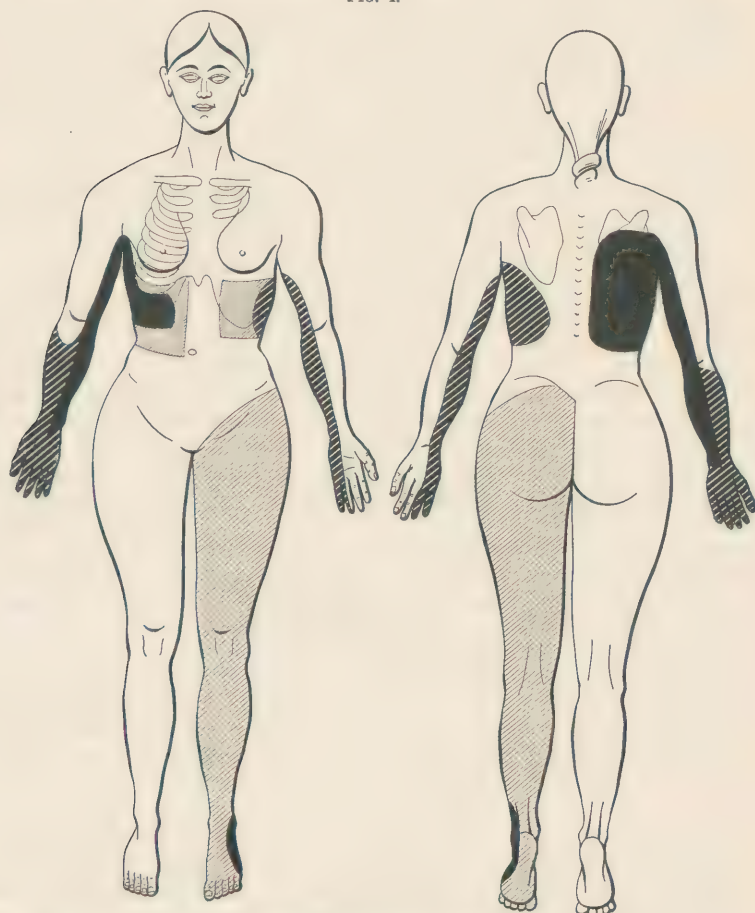


Hyperaesthesia to pain. Tactile anaesthesia.




* The low pain threshold made this difficult of demonstration. Touch with a wisp of cotton sometimes felt "sharp" to the patient.

complete retrogression of motor paralysis in the leg except for some weakness in Mann's residuary hemiplegic group. Slight paresis in the right arm persists, with reduced irritability of all muscles below the triceps

FIG. 4.



Heat and cold (sixth month).

- | | | |
|---|--------------------------------------|--|
|  | <i>Areas of Extreme "Cold Pain."</i> | } <i>Heat and Cold
recognized as such,
though perception dulled.</i> |
|  | <i>"Cold Pain" less marked.</i> | |
|  | <i>Cold produces slight pain.</i> | |

level to galvanic and faradic stimuli. Paralysis is apparently complete, with atrophy, in the abductor indicis alone, but the muscle responds feebly to both currents, whether applied directly or transmitted through the nerve. The contraction to galvanic is very slight and slower than normal.

The deep reflexes remain exaggerated on the right side. There is a patellar and ankle-clonus. Myotatic contractions also in the muscles of the arm are elicited with ease. The increased muscular tone tends to hold the arm quite rigid, so that passive motion meets with marked resistance. The extent of mobility in the joints is quite limited. Forced motion causes severe pain, especially in the shoulder and phalangeal articulations. This is most pronounced in the little and ring-fingers, which are very stiff.

Some trophic disturbances persist in the fingers, which are tapering and somewhat shiny. The nails are curved and brittle, and the patient thinks they grow much faster than on the other hand.

Subjectively, there is great annoyance from pain, described as "darting and burning," in the arm, especially referred to a region on the anterior surface above the wrist. These sensations, at times spontaneous, are aggravated by any exposure, especially to cold. A chance drop of cold water makes her cry out.

Sensory disturbances persist as follows (May 20, 1897, one hundred and ninety-five days):

1. *Disturbances of pain and touch or pressure.* (Fig. 3.) There is slight anæsthesia to pain and a very slight but distinct dulling of sensibility to touch or pressure (tested by a soft camel's-hair brush) over the areas of original anæsthesia. This is not true, however, for the right arm. Here, by a comparison with Fig. 1, we find that the original segmental area of anæsthesia has been replaced by one of great hyperæsthesia. The segmental sensory paralysis has receded to a level below that of the residual segmental motor paralysis, which persists in muscles corresponding to the eighth segment. It is now limited to the half zone on the chest, from the second to the fifth interspace and only in front. There is a half zone of hyperæsthesia below this. The area below the external malleolus on the left not noticed as differing from the rest of the left side at entrance, and perhaps overlooked, now shows a marked hyperæsthesia to pain and cold stimuli and a greatly lowered sensibility to touch or pressure.

2. *Thermic disturbances.* (Fig. 4.) *Cold* at present is nowhere interpreted as heat. It gives its proper thermic sensation, though perhaps dull. Over the areas in black (Fig. 4) the pain threshold to cold remains very low. Some pain is called forth over the right leg which heretofore had not been observed.

Heat is everywhere recognized as such, but is much dulled over the whole left side below the second interspace and over the right segmental areas of the arm and chest, where a high temperature feels barely warm.¹

THE NATURE OF THE SPINAL LESION. A variety of morbid processes might have produced a symptom-complex similar to the foregoing. With the data at hand an absolute diagnosis is precluded, and conclusions may only be drawn from the few reported cases of a similar nature which have allowed of subsequent examination.

¹ There seems to be considerable variability in the patient's recognition of thermic stimuli. An examination in December, 1897, revealed the following condition on the left side:

Tactile perception normal; common sensibility (pain) slightly dull; cold, even when near body temperature, is "hot," and ice "burns;" heat feels but slightly warm, even when near the boiling-point. The condition otherwise was much as on May 20th.

A crush of the cord from vertebral subluxation, with immediate reduction, as is supposed to happen in acute flexures of the spine, is a most commonly ascribed injury, especially in this region of the column. Further, a laceration of the cord from fracture, by a spicule of bone torn off by the missile, or from the missile itself, might be the offending process, or, lastly, hemorrhage, whether into the membranous envelope of the cord (hæmatorrhachis) or into the very cord substance (hæmatomyelia).

Mitchell, Morehouse, and Keen,¹ who had such exceptional advantages for observations of gunshot injuries of nerves, drew especial attention to the fact that the mere passage of a bullet near the spine may so jar the delicate organization of the cord as to cause paralytic symptoms. To this condition they gave the name commotion or concussion of the spine, from the belief that the comparatively transient nature of most of the symptoms was not compatible with the existence of any gross lesion. Commotion and concussion, however, seem merely to imply a degree of hæmatomyelia with minute hemorrhages into the cord, and, as we shall see, extensive destruction from intramedullary hemorrhage may be followed by restitution, almost complete as that of the cases included under this heading. Thorburn² accounts for the lesion in his series of cervical cases in which, at autopsy, no injury of the spinal column was demonstrable, by a subluxation, as described above, due to supposed acute flexures of the neck. We can hardly imagine in our case that a bullet of 32-calibre, especially with a lateral blow, could cause such a subluxation with a resultant injury to the cord, though the results were the same as observed by him. Also considering the position of the bullet as demonstrated by the skiagraphs, lodged in the centrum of one of the vertebræ, its whole course having been anterior to the arches, it does not seem likely that a laceration of the cord could have been produced by any dislocated spicule of bone.

Between hæmatorrhachis and hæmatomyelia no absolute means of differentiation have been laid down, which is unfortunate from an operative stand-point. There is a great difference of opinion as to their relative frequency. Manley,³ partly from post-mortem observations and partly from his inability to produce it experimentally, has claimed that intramedullary hemorrhage is of great rarity. He stands practically alone in this assertion. Thorburn believes that the number of cases of traumatic hæmatomyelia is much underestimated. Six out of his twenty-one cases of injury to the cervical spine showed hemorrhage into the cord and unaccompanied by any apparent injury to the column itself. In but

¹ Mitchell, Morehouse, and Keen : Gunshot Wounds and Other Injuries of Nerves, 1864.

² Op. cit., page 64.

³ Manley : "Traumatic Lesions of the Spine." etc. Abstract in Journal of Nervous and Mental Diseases, 1891, xvi. p. 350.

one of his cases¹ did he question the possibility of meningeal hemorrhage, and then only because he could not believe in the existence of intramedullary hemorrhage without destruction of the ganglion cells of the ventral horn and consequent atrophic paralysis in some muscles of the upper extremity. That this muscular atrophy may not occur, and yet there be extensive hemorrhage into the anterior horn and destruction of motor cells, is well illustrated by Mann's case,² the similarity of which to Thorburn's and to our own cannot but confirm a belief in the presence of a similar lesion. In addition there was a distinct history of pyramidal tract degeneration. In another of Thorburn's cases (Case XV., p. 43), one of dislocation of the fifth cervical vertebra, similar paralyzes, motor and sensory, resulted. The disturbances in the arms he believed to have been occasioned by pinching of the peripheral nerve-roots on one side and dislocation on the other. A true spinal hemorrhage could more simply have accounted for the whole lesion. The condition of the reflexes and all else was very similar to the one under discussion. Contrary to Manley's view, the literature appears to point to the comparative infrequency of the meningeal form. Parkin³ reports a series of these cases, all of intramedullary hemorrhage. The observations of Minor⁴ in five cases, and of many others, lend confirmation to this view.

Clinically, the two are often impossible to distinguish. Their symptom-complex is very similar, and in both there is the same apoplectiform onset. In meningeal hemorrhages the chief stress is laid upon the irritative phenomena. Acute and immediate spinal pain, increased by spinal movements, is a constant symptom. Radiating (ausstrahlenden) pain from the supposed pressure of the blood on the spinal roots, and referred over their distribution, is also most characteristic, and on it Kocher lays especial stress. In our case, though there was great complaint of "pain," it was not of a radiating character, nor was there any localized spinal sensation. The "pain" was felt as a "being asleep" (what the Germans describe as *Eingeschlafensein*), and it extended over a wider area than could be accounted for by peripheral irritation. In the intramedullary cases, on the other hand, the paralytic symptoms of motility or sensibility are most in evidence, and, for reasons to follow, are very commonly combined in the Brown-Séquard type. These paralytic phenomena progress rapidly, and soon after the attack reach their full development. They may be accompanied by pain, as Leyden⁵ suggests, either through lesion of the dorsal horn itself, or by compression on the dorsal roots, caused by the swollen cord, different in character, however,

¹ Op. cit., Case XXI.

² Loc. cit., Fall vi.

³ Alfred Parkin: "Seven Cases of Intraspinal Hemorrhage (Hæmatomyelia)." *Guy's Hospital Reports*, 1892, lxxviii. p. 107.

⁴ S. Minor: "Central Hæmatomyelie." *Archiv f. Psychiatrie*, 1892, xxiv. p. 694.

⁵ Leyden-Goldscheider: "Die Erkrankungen des Rückenmarkes und der Medulla Oblongata." *Wien*, 1895.

from the radiating pains spoken of. Hyperæsthesiæ, phenomena of motor paralysis in the lower extremity, reflex disturbances, including those of the bladder and rectum, may occur with hemorrhage at either site, and when at the level of the cervical enlargement, brachial diplegia from implication of the centres themselves or of the peripheral nerve-roots. These symptoms are of much shorter duration, however, in the meningeal form, and though the case under discussion showed a rapid subsidence of many of its symptoms, the evidence of descending degeneration of the right pyramidal tract and the persisting sensory picture, so closely akin to syringomyelia, together indicate an insult to the cord-substance, which pressure from meningeal hemorrhage could not have produced. The existence of a combined lesion, of course, is possible, but unlikely. A particular feature brought out by Thorburn's extensive series of observations was that hæmatomyelia existed in no cases other than in the cervical one. He says,¹ "above and below this section of the cord I have not met with a single instance of traumatic hæmatomyelia." This he attributes to the fact that many of his cases were caused by acute flexion of the neck, with supposed temporary vertebral displacement, the action of which from the anatomy of the column would be felt in the lower part of the cervical enlargement, producing hemorrhage, though without demonstrable injury to the spine itself. He thus accounts for the limited focus of the lesion, holding the concussion theory untenable from the belief that a bruise would show itself spreading over a larger and less sharply defined area. Similarly, Parkin's six cases were of intraspinal hemorrhages and at this same definite cervical area. From a further study of recorded cases it seems that not only those cases attributable to acute flexions of the neck, but also those in which this presumably did not occur, as from falls on the back without flexion of the neck,² lateral flexion,³ direct violence,⁴ hyper-extension,⁵ the few gunshot injuries reported,⁶ and various forms of traumatism, as from being run over,⁷ all give a similar picture. In a few

¹ Op. cit., p. 64.

² Mann : Loc. cit., Fall vi. Thorburn : Op. cit., Case 18.

³ Barling. "Injury to the Cervical Spine. Hæmatomyelia with Paralysis." Birmingham Medical Review, 1893, xxxiv. p. 149.

⁴ Thorburn : Op. cit., Case 16.

Hans Schmaus : "Beiträge zur pathologischer Anatomie der Rückenmarkerschütterung." Virch. Archiv, 1890, cxxii. p. 326, Beobacht. III.

⁵ Parkin : Loc. cit., Case 2.

⁶ Charcot : "Sur un cas de paralysie radicaire de la première paire dorsale, avec lésion hémilatérale de la moelle, d'origine traumatique simulant de syringomyélie." Archiv. de Neurologie, 1891, xxii. No. 65.

Haven : "An Unusual Case of Gunshot Wound of the Cervical Spine." New York Medical Record, February 15, 1896, xlix.

Thorburn : Op. cit., Case 21.

Preston : "Brown-Séquard Paralysis, with Report of a Case." Journal of Mental and Nervous Diseases, October, 1896, xxi. p. 645.

J. K. Mitchell : Op. cit., Case 31.

⁷ Stenbo : "Ein Fall von centraler Hæmatomyelie." St. Petersburg. med. Woch., 1894, Bd. xix. S. 128.

Thorburn : Op. cit., Case 19.

cases, where a bullet lodged at a region slightly remote, as in the upper dorsal or middle cervical regions, did a similar definite localization of symptoms result.

It is well recognized that intramedullary hemorrhage selects the gray matter of the cord, presumably from the less firm support given to the vessels there. In the cervical enlargement where the amount of gray matter is large the condition would be favored. The fact, however, that the hemorrhage is, with few exceptions, into the same level of this enlargement, picking out with little variation primarily the same segmental area, is strongly suggestive of the fact that there exists in the gray matter of the lower cervical enlargement a certain vessel or vessels which are less resistant to traumatic forces and more apt to give way, just as under diseased conditions in the brain one particular vessel, namely, Charcot's artery of cerebral hemorrhage, is the one most apt to rupture under any especial strain.

The similarity of the reported cases is most striking throughout their whole progress. In illustration, probably all of Thorburn's cases; five of Parkin's six cases, with post-mortem confirmation in four; Minor, in five cases from cervical trauma, in his article on "Central Hæmatomyelia;" Hoch, Lloyd, Stembo, Shigago, Wilkens, Schmaus, Robinson, and others, as in the gunshot cases above cited, all report cases with hemorrhage at this level; while at other regions, unless there is some gross spinal lesion with deformity, traumatic hæmatomyelia is of comparative rarity. We, perhaps, may look upon the lower cervical enlargement up to the triceps level as the site of predilection for hæmatomyelia¹ of traumatic origin, its primary focus being at the eighth cervical segment.

Few of the cases, however, have allowed of subsequent examination, and for that reason Mann's² article sheds much light on the extent of lesion compatible with practical recovery.

His case, though the symptoms were slightly more intense than in the one here recorded, is so much akin to it, the lesion in both being situated at this elective site, the symptoms in both representing a type of the so-called Brown-Séquard paralysis, that his post-mortem findings are of especial interest. At the time of necropsy, three years after reception of the injury, there remained symptoms almost the counterpart of the present residuum in our case, except for the persistence in his of the bilateral intercostal paralysis which was indirectly the cause of death.³

¹ Berkley ("Syringomyelia." *Brain*, 1890, xii. p. 465) has pointed out the fact that in primary hæmatomyelia, non-traumatic, the cervical enlargement is the favorite seat.

² Mann: *Loc. cit.*

³ The examination in Mann's case showed a tract of descending degeneration in the posterior columns which led to the hypothesis that it was a special path subserving the motor function of the intercostal muscles. This may illustrate an especial provision on the part of nature to protect the vital process of respiration. In the case of Parkin's, in which the phrenic centre was involved and also paralysis of the lower extremities, showing pyramidal tract involvement, the costal and abdominal muscles were intact, which is interesting in this connection.

Mann's findings at autopsy showed the spinal membranes intact, a unilateral cavity representing the old hemorrhage limited in level to the eighth cervical segment, with practical complete absence of all nerve elements on one side. There was a partial destruction on the opposite side, where almost the whole gray substance was transformed into connective tissue, and, though but few ganglion cells were recognizable in the anterior horn, no atrophic paralysis had resulted in the muscles of the corresponding upper extremity.

The pathology of these cyst-like cavities resultant to localized hemorrhages is carefully described by Leyden¹ and others.² Goldscheider, by injection into the cords of cadavers, found that the gray substance and chiefly the posterior horn is favorable to the spread of hemorrhage, which well explains the frequent persistence, as in our cases, of the symptoms of syringomyelia. This association of traumatism with syringomyelia has often been noted.³ In cases in which the symptoms of this affection appear suddenly or even at a later date, we may with probability suspect the occurrence of hæmatomyelia. Their similarity was first noted by Minor⁴ and the relation of the hemorrhagic cavity formation to the syringomyelia syndrome by Langhans and Kronthal. Robinson,⁵ Lloyd,⁶ Bruhl,⁷ Stembo,⁸ and others have called attention to it, and its occurrence was noted in many of the cases above referred to.

The conclusion, that the great majority of these cases are of intramedullary hemorrhages, from a surgical stand-point, is distinctly disappointing, as the meningeal form alone seems at present to offer hope for operative interference. In the cases which have come to operation it would seem that the myelitis which the further trauma of the cord has produced is most apt to carry the paralysis to a point higher than that of election, so producing death from dyspnoea, due to involvement of the phrenics.

THE SITE AND EXTENT OF INJURY. This ordinarily offers less diagnostic difficulty than its nature, though, at an early period following its reception, shock may mask somewhat the degree of interruption of the conducting paths.

1. *The level of lesion.* The upper limit of this on the right side we may locate with comparative precision both by the motor and the sensory disturbances. It corresponds exactly to the lesion of the cervical

¹ Loc. cit., p. 347.

² Bruhl: "Syringomyélie," Thèse, Paris, 1889-90; Mann: loc. cit.; Minor: loc. cit.

³ Reynès: "Hémi-anesthésie et Hémi-paralysie croisées (Syndrome de Brown-Séquard) suite de Commotion Médullaire." *Gaz. des Hôpitaux*, Paris, March 28, 1895.

⁴ Minor: "Beitrag. zur Lehre der Hæmato- und Syringomyelie." *Verhandl. des X. internat. med. Cong.*, Bd. iv. S. 4. Berlin, 1890.

⁵ Robinson: "Sur un cas de Syringomyélie débutant comme une Hæmatomyélie." *Journal de Méd. de Paris*, 1891, p. 90.

⁶ Lloyd: "Traumatic Affections of the Cervical Region of the Spinal Cord Simulating Syringomyelia." *Journal of Nervous and Mental Diseases*, 1894, xix. p. 345.

⁷ Bruhl: Op. cit.

⁸ Stembo: Loc. cit.

cord which Krauss¹ designates as the "typus inferior," in contradistinction to the "typus superior" of cervical enlargement lesions, the triceps apparently being the hinging point between the two and ordinarily involved with the former type. It reaches Thorburn's "fifth" root group. Comparison with Starr's familiar table² shows that the "high-water mark" of injury, as shown by muscular involvement, included the sixth cervical segment and affected to a degree the fifth, for there was distinct paresis of deltoid, biceps, supinator longus, etc.

On the left total interruption of function was limited to the eighth segment, possibly due to compression alone on the anterior horn, for there was no pyramidal tract involvement, and, as we shall see, this is opposite the site of the chief injury. It must be remembered, however, that Sherrington has proved that individual muscles are represented by more than one segment, and the animal experiments of Ferrier and Yeo³ show that section of one nerve root merely spoils a certain elaborate co-ordination movement without paralysis of any one muscle, so that only approximately from the motor paralysis may we estimate the level of the lesion.⁴

By the sensory symptoms it may often be located with more exactness, despite the fact of the overlapping of sensory root cutaneous fields noted by Sherrington,⁵ for Head⁶ claims that the tactile fields alone overlap, while those for thermic and pain impressions do not, making them of chief value in segmental localization.

The upper limit of sensory disturbance must be sought in the arms, for the thoracic level in cases of cervical lesion remains constant at the second or third rib, corresponding to the distribution of the descending branches from the cervical plexus. Our case being of the nature of a right hemilesion, we look to the left arm and find that the area of anæsthesia to pain and temperature includes the D_I. segment of Kocher's⁷ figures, the D_I. and CVIII. segments by Starr,⁸ which corresponds to the final level of residuary motor disturbance in the right arm. Reid⁹ has carefully studied the relation of the cervical spines to the various

¹ Krauss: "Die Bestimmung des betroffenen Rückenmarksegmentes bei Erkrankungen der unteren Halswirbel." *Zeitsch. f. klin. Med.*, 1890, Bd. xviii. p. 343.

² M. Allen Starr: "Local Anæsthesia as a Guide in Diagnosis of Lesions of Upper Portions of the Spinal Cord." *Brain*, London, 1894, xvii. pp. 481-511.

³ Ferrier and Yeo: *Proceedings of Royal Society of London*, March 24, 1881, No. 212, p. 12. "The Localization of Atrophic Paralysis." *Brain*, London, 1882, vol. iv. p. 217.

⁴ The uncertainties of localizing cord lesions by motor paralysis alone are thoroughly discussed by Bastian. *Quain's Dictionary of Medicine*, ii. p. 811.

⁵ Charles S. Sherrington: "Experiments in Examination of the Peripheral Distribution of the Fibres of the Posterior Roots of Some Spinal Nerves." *Transactions of Royal Philosophical Society of London*, 1893, clxxxv. B. p. 641.

⁶ Henry Head: "On Disturbances of Sensation with Especial Reference to the Pain of Visceral Disease." *Brain*, 1893, xvi. p. 1.

⁷ Kocher: See diagrams; loc. cit.

⁸ Starr: See diagrams; loc. cit.

⁹ R. W. Reid: "The Relations between the Superficial Origins of the Spinal Nerves from the Spinal Cord and the Spinous Processes of the Vertebrae." *Journal of Anatomy*, 1889, vol. xxiii.

cord segments, and though there is slight variation the CVIII. segment corresponds to the sixth cervical vertebra, and the evidence of the skiagraph showing the bullet impacted in the body of this vertebra was gratifying, though, as before suggested, a similar lesion might have been produced by its lodgement anywhere in the vicinity.

The disturbed sensory areas on the right naturally reach a higher level, namely, to that which was spoken of as the "high-water mark" of motor paralysis, the fifth root level, as interruption of their fibres occurs on the side of the lesion and before decussation. The vertical extent of injury is less satisfactorily told. It is supposed to correspond to the breadth of the zone of anæsthesia on the side of injury, which reached the sixth rib in front and lower on the back. Further, the motor paralysis on the opposite side might help to decide this. It included, however, the thoracic and abdominal muscles, which seems an unlikely extent of hemorrhage, and which cannot be accounted for unless we accept Mann's interesting suggestion of an especial motor path subserving these respiratory muscles.

2. *The extent of lesion.* An early recognition of the degree of spinal cord injury often is impossible, as the symptoms depending on actual destruction may be complicated by those due simply to compression and degenerative changes. The above case, as did Mann's, presented features of a partial transverse lesion of the type of hemiplegia spinalis, though some of its symptoms passed beyond those of a pure hemilesion, and indicated an actual involvement of the gray matter of the opposite side, more extensive than could be explained by pressure or oedema. These symptoms, indicating more than a unilateral lesion, were as follows:

1. The relatively large extent of sensory disturbance on the right, the side of motor paralysis, going beyond the usual zona anæsthetica of hemilesion, and only explicable by the assumption of a lesion on the left side extensive enough to destroy a part of the sensory paths already crossed in addition to the segmental fibres on the right entering at the level of lesion.

2. The temporary paralysis of the left upper extremity and augmentation of reflexes on that side. They should be unchanged in pure unilateral injury.

3. The bilateral paralysis of the intercostal and abdominal muscles.

4. The involvement of the bladder and rectum, which in pure hemilesions does not occur.

5. A temporary lowering of the sense of touch on the side of lesion. Though Kocher has noticed this condition in a case of hemilesion, it is possibly due to some involvement, more than unilateral, of the various tracts subserving tactile impressions.

With these exceptions the clinical symptoms correspond to those of

hemilesion at the cervical enlargement. With some reserve, and with no attempt at physiological explanation, the following picture, adapted

FIG. 5.



CASE I.—Skiagraph showing bullet in the sixth cervical vertebra.

from Kocher and illustrated by our case, is given as the interpretation of the so-called Brown-Séquard paralysis in this instance of cervical hemilesion. This, it will be noticed, differs from the original concep-

tion,¹ which had to be modified as a result of the recent investigations of Mott² and others, and was renounced even by Brown-Séquard himself.

On the injured side. 1. Motor paralysis of the lower extremity, to

FIG. 6.



CASE I.—Lateral view.

disappear in a few weeks, presumably through the decussating neurones of the opposite side (Turner). These reserved fibres are believed (Edinger) to pass from the anterior tract through the anterior commissure³

¹ Brown-Séquard : *Journal de Physiologie*, 1863, pp. 124 et seq.

² F. W. Mott : "Results of Hemisection of the Spinal Cord in Monkeys." *Transactions of Royal Philosophical Society*, 1892, clxxxiii. p. 1.

³ v. Lenhossék ("Der feinere Bau des Nervensystems im Lichte neuester Forschungen." ii Aufl., Berlin, 1895), in extremely careful studies of the human cord by Golgi's method, has, however, never been able to find any axones from the anterior pyramidal tract which passed through the anterior commissure to the anterior horn of the opposite side. He believes that the fibres of the anterior tract terminate in the anterior horn of the same side.

to the opposite anterior horn, playing a larger rôle for the leg than the arm.

Paralysis of intercostals and abdominal muscles on this side, perhaps subserved by a special path (Mann), to disappear at a later time, also possibly by decussation.

Atrophic flaccid paralysis of those muscles in the upper extremity, representing destruction of anterior horn ganglion cells, though by no means corresponding to its extent, and practically absent here.

2. Atrophy, temporary, of muscles of the same side more than can be accounted for by inactivity.

3. Paralysis of vasomotor fibres, temporary, with elevation of surface temperature of paralyzed side.

4. Early diminution or abolition following diminution of deep reflexes, with subsequent exaggeration and spastic condition, as in the animal experiments of Ferrier and Yeo. (An explanation might be given of this abolition by supposing only a partial interference of function of this half of the cord, rendered complete in a few days by a spreading myelitis, but there was no other evidence of such a process.)

5. Temporary suspension of muscle-sense. (The whole question of the disturbance of muscle-sense and pressure-sense in Brown-Séquard paralysis remains still *sub judice*. Experimental and clinical data give many contradictory results.)

6. Hyperalgesia of the whole side below a segmental zone of analgesia which corresponds to the level of lesion. Thermic and tactile anæsthesia may also be present over this zone, but are elsewhere unimpaired. A lowered sensation of touch is said to occasionally occur in man (Vix and Kocher). (There was a slight lowering in our case, but it was supposed to have been occasioned by the more than unilateral nature of the lesion, for consensus of opinion would lead to the belief that in pure hemilesion tactile sense remains unimpaired except over the zone of anæsthesia corresponding to and on the side of the lesion.)

7. Oculo-pupillary symptoms; these being contraction of the pupil, slight ptosis, narrowing of the palpebral fissure, and diminished tension of the globe (Kocher), with hyperæmic changes in the disk (Thorburn). (These symptoms were not noted in our case. Either the involvement of the opposite half of the cord was sufficient to affect the centrum cilio-spinale there as well, and prevent any marked asymmetry of symptoms on the two sides, or the examination was not made with sufficient care till a later date, when they were certainly absent.)

8. Disturbances of the vesical, anal, and priapismic reflexes may be wanting in pure hemilesion, though always an accompaniment of total transverse lesions.

On the opposite side. Elective sensory paralysis, which varies in intensity and quality in different cases. Touch, in our case slightly

dulled, is often unaffected, paths for its conveyance being probably more than single in the cord, and perhaps uncrossed. Anæsthesia to pain, heat, and cold, usually complete and often permanent, here were temporary. The lateral limiting layer, looked upon with great definiteness as a path for these crossed sensory fibres (Edinger), from its proximity to the gray matter, naturally receives a serious injury in hæmatomyelia. That the analgesia disappears as the hyperæsthesia of the opposite side diminishes (Kocher) was here observed. The thermic sensibility partially returns, if at all, only after restoration of pain, and then of tactile sensibility, if the latter has been disturbed. The sensation of heat may return first and of cold later (Rosenthal).

In conclusion, attention is drawn to the following points:

1. Paralytic symptoms following traumatism in the cervical region, when there is no resultant spinal deformity or laceration of the cord, are in the majority of cases due to hemorrhage into the substance of the cord.

2. For this hemorrhage there seems to be a site of predilection in the lower part of the cervical enlargement, producing the symptoms of the "typus inferior" of Krause.

3. The hemorrhage, as a rule occurring primarily on one side, leads to symptoms of a Brown-Séquard type of paralysis.

4. The deep reflexes on the side of hemilesion may be retained for a time, then disappear and finally return, to become exaggerated

5. The hemorrhage, being primarily into the gray matter, and in its resolution often leading to cyst formation, is productive in many cases of a symptom-complex quite like that of syringomyelia.

6. The immediate prognosis¹ of this type of hæmatomyelia is good without operative interference, even in the cases of gunshot wound when they are uncomplicated by sepsis.

I wish to express my indebtedness to Dr. Lewellys F. Barker and to Dr. H. M. Thomas for their kindly interest and aid in the preparation of this report.

Since the completion of the above report there has been admitted into the wards of the hospital a similar case of gunshot wound of the spine, preliminary note of which is here given. The injury was in the dorsal region, and except for the differences due to this lower level of lesion, and its limitation absolutely to one side, the symptoms were a mild counterpart of those in Case I. The clinical picture was that of a pure Brown-Séquard paralysis.

CASE II.—The patient, a boy aged fourteen years, was shot in the back November 20, 1897, with a 22-calibre revolver. He fell to the

¹ A late prognosis is more uncertain. J. K. Mitchell (op. cit., p. 103), in following up the histories of cases of spinal trauma occurring twenty-five years previously, arrived at the important conclusion that "no seemingly perfect return to health, even though it should have lasted several years, will bar out the possibility of late sclerotic and other changes."

ground, without loss of consciousness, and found that he could not move his left leg. Examination on admission, twenty-four hours after the injury, reveals a small wound of entrance 5 cm. to the right of the seventh dorsal spine. The skiagraph shows the bullet lodged in the centrum of the eighth dorsal vertebra. The left leg is completely paralyzed and hyperæsthetic; the right anæsthetic to all stimuli but that of touch. The patient complained of numbness in his left leg, as though it were asleep, and there is a sensation of tightness about his abdomen, and lancinating pains which are augmented by the slightest touch and which correspond to a belt of great hyperæsthesia.¹ (See Fig. 7.)

SYMPTOMS AND PROGRESS. *Motor symptoms:* Paralysis remained complete in the left leg until the fifth day, when motion was first observed as a slight contraction of the quadriceps femoris, so that he could partially straighten his leg when flexed. Motion in a few days was possible in all directions. At present a marked paresis remains in the dorsal flexors of the foot, as well as in the rest of Mann's group, which gives the patient the dragging gait of a hemiplegic. He was up and walking about by the third week. No loss of muscle-sense could be detected at any time.

The reflexes: On the left, the side of the paralysis, the same sequence was observed in the deep reflexes as in Case I., viz.: forty-eight hours of persistent and moderate activity, followed by complete abolition for three days, with a subsequent return and progressive augmentation. At present there is a most active ankle and patellar clonus, and myotatic contractions are also produced in the gluteus and hamstring muscles by tapping on their tendinous insertions. On the opposite side there was a slight exaggeration of the deep reflexes at first; since, they have been normal. Superficial reflexes, both plantar and cremasteric, were absent on the left side for the first week or two. There was considerable difficulty in evacuation of the bladder and rectum.

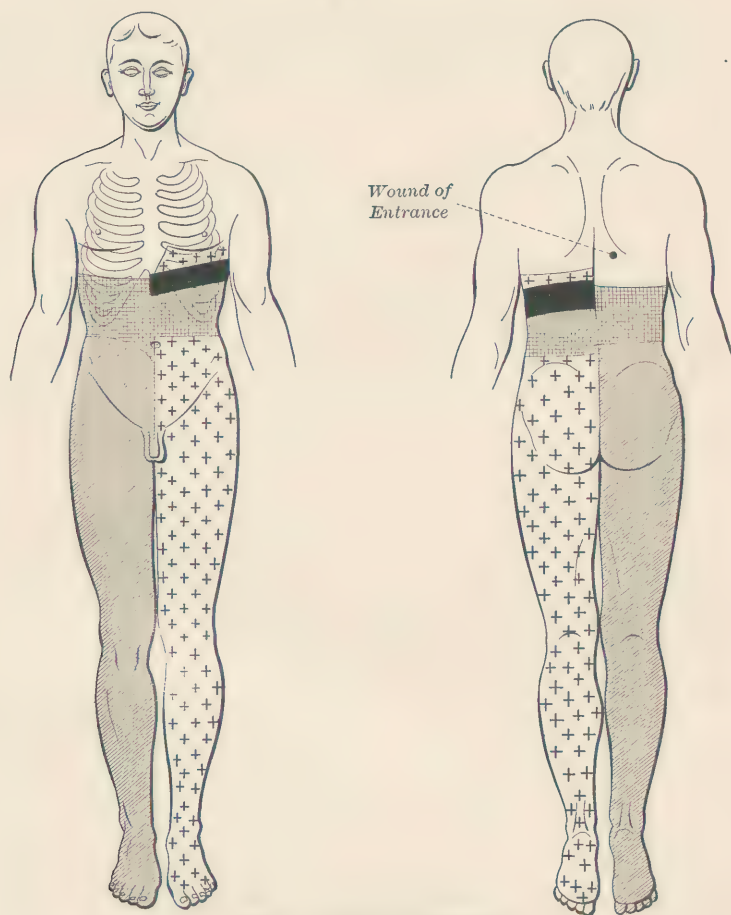
Sensory symptoms. (Fig. 7.): *Touch* was unaffected, except for a small zone on the paralyzed side at the level of the lesion. This narrowed and was lost by the second week. *Pain:* The analgesia of the right leg, observed at entrance, had disappeared by the third week, as had the hyperæsthesia on the left. In a zone about the body, however, hyperæsthesia was extreme, and over it all stimuli called forth especial pain. A slight degree of cold would bring tears to the patient's eyes. This zone gradually disappeared from the right and receded into a small area on the left side, where it persists. *Thermo-anæsthesia* was present on the right leg, where all stimuli were recognized as slight warmth. As in Case I., a small area under the internal malleolus was observed during the third week, where cold was recognized as such and caused pain. This area of returning thermic sensibility, associated with some hyperæsthesia, gradually spread up the leg and had in a month reached the knee, below which varieties and degrees of thermic stimuli were readily recognized.

In both of these cases, therefore, following the lodgement of a bullet in the body of a vertebra have appeared symptoms of spinal lesion, with

¹ It is noteworthy that this cutaneous hyperæsthesia produced a protective spasm of the abdominal parietes, just such as intraperitoneal inflammation calls forth, and had not the bullet been located by the x-rays in the vertebra, it would have been difficult to believe that there was not a penetrating wound of the abdomen from behind.

apoplectiform onset and a Brown-Séquard type of paralysis. Pyramidal tract degeneration has resulted, leaving its residuary paralysis in

FIG. 7.



Case II. Condition at entrance.

 *Total Anaesthesia.*

 *Analgesia. Thermoanaesthesia.*

 *Hyperaesthesia.*

 *Extreme Hyperaesthesia espec. to thermic stimuli.*

the lower extremities and, in Case I., involvement of ventral horn ganglia of the cervical enlargement has resulted in trophic changes

with atrophy of some muscles. In each a residuum of sensory disturbances on the anæsthetic side persists as partial thermo-anæsthesia, and over a zone below the level of the lesion and on the same side remains some hyperæsthesia to pain which cold stimuli especially call forth. On the side of lesion in both cases the deep reflexes were retained for a time, then lost, and finally returned to become permanently exaggerated.

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